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GB 2267407 A GB 2166317 A EP 0300365 A2

(58) Field of Search
UK CL (Edition O) H4F FCCB FCCX FCCY FCK FKX
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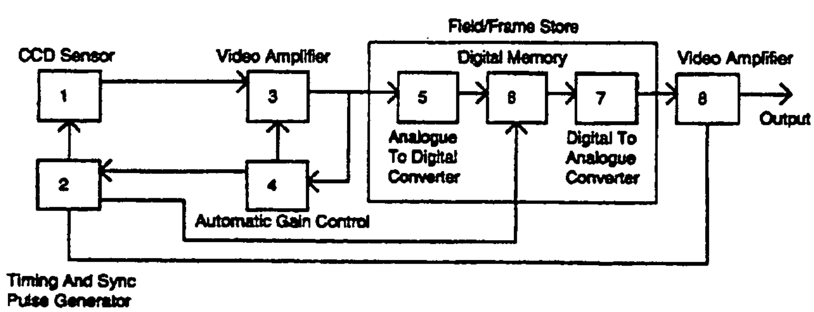
(54) **Extended integration period video camera**

(57) A video camera suitable for use in extreme low levels of illumination, utilising extended integration periods by incorporating an image memory. The memory allows operation with integration periods that considerably exceed the period of a normal output frame, while retaining full compatibility with existing signal standards (e.g. 625/50 PAL). Since a CCD sensor is 'reset' by a read operation, the image is available only once from the imager itself. This image is stored then replicated as many times as is necessary to fill the period being used to integrate or acquire the subsequent image. The basic technique may be applied to most types of camera, but is especially applicable to the CCD type. Both monochrome and colour cameras are suitable, for the colour type this can be either the single or multi - chip type. For the colour camera, the memory placement can be before or after the colour encoder. Advances in semiconductor fabrication techniques may soon allow an analogue or digital storage device to be integrated into the sensor chip itself.

4. CCD Camera With AGC, Shutter Control, And Extended Integration



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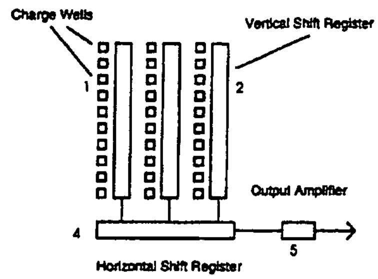
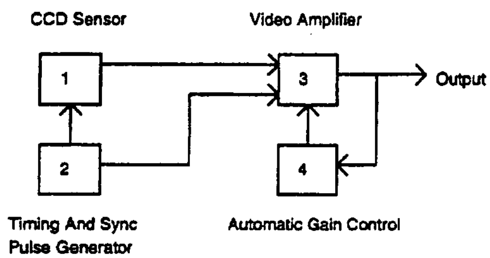
At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

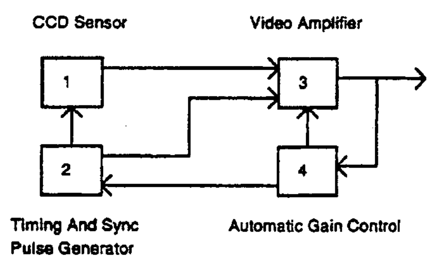
1. **Example Charge Coupled Device (CCD)**



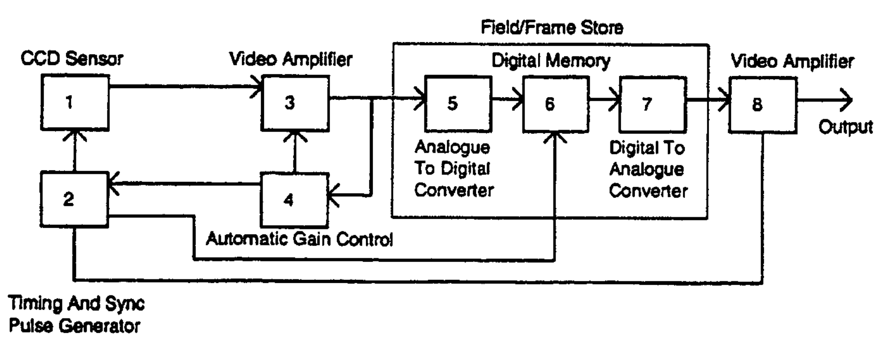
2. **Typical CCD Camera With Automatic Gain Control (AGC)**



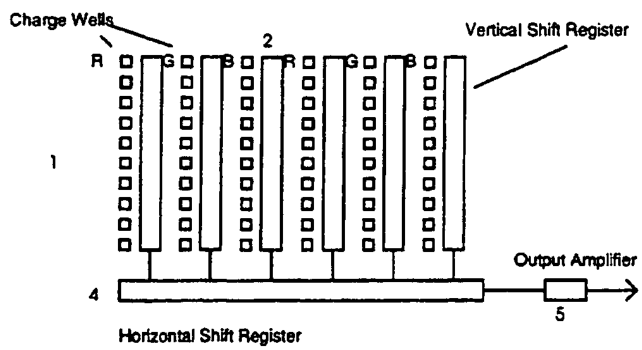
3. **CCD Camera With AGC and Electronic Shutter Control**



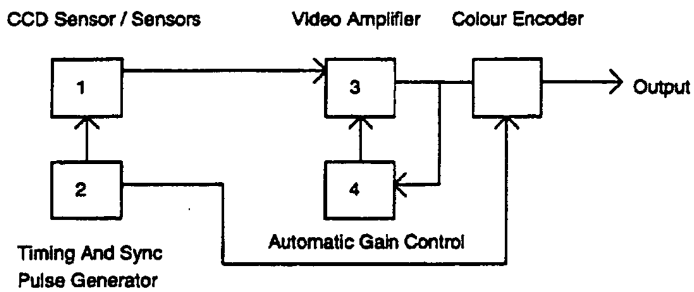
4. **CCD Camera With AGC, Shutter Control, And Extended Integration**



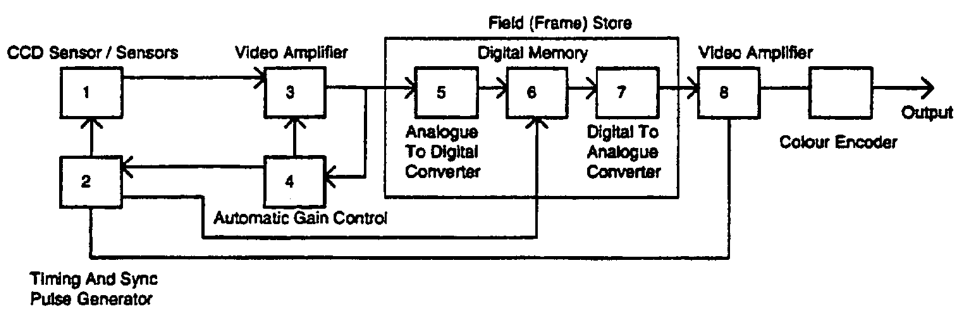
5. Exampl Colour CCD, Single Chip Type



6. Typical Colour CCD Camera



7. Colour Camera With Extended Integration



Background

A video camera is an opto-electronic device, which produces an electronically encoded output (a 'video signal') representing the view 'seen' by the camera. To display this signal as a visible picture requires a compatible display device, usually known as a monitor. The video signal may also be recorded for future viewing or analysis using a compatible video recorder, or captured by a compatible computer for a variety of purposes.

Internationally, there are many standard formats for the video signal. The standard currently used in the UK (and some other countries) for virtually all domestic, commercial and scientific applications is 625 line 50Hz PAL. This system has several distinguishing characteristics, which include a frame rate of 25 Hz (25 interlaced pictures per second) and 625 horizontal 'scan' lines making up each picture. "PAL" is actually a term which relates to the way that colour information is encoded into the signal. The PAL system was developed from, and to be compatible with, monochrome (or 'black and white') 625 line equipment. The PAL video system (or its monochrome sub-set) exists in the UK to almost the complete exclusion of all others. This standardisation results in a wide range of compatible equipment being readily available. Throughout the following descriptions, use of the term "PAL" is intended only as an example relevant to the UK. Similar arguments would be equally applicable to alternative systems in other countries.

Surveillance and security systems using video are commonplace. For domestic application, the display or recording of video pictures is readily accomplished using existing broadcast equipment, which will be PAL compatible. It is clear, therefore, that a cost effective domestic CCTV (Closed Circuit TV) system requires a PAL compatible video camera. Infact, the most cost effective solution to almost all video requirements will be to use 625 line PAL compatible equipment, on account of the vast choice and competitive pricing.

Most video cameras now use solid state CCD (Charge Coupled Device) sensors to capture the image, and for this reason the following descriptions assume CCD imager technology. The optical parts of these cameras have many features and characteristics in common with photographic cameras. There is a lens to focus the image onto the sensor, and often an 'iris' which is used to control the level of illumination which reaches the sensor. In strong lighting conditions, the 'aperture ' of the lens is reduced using the iris, which is necessary due to limitations of the sensor. There is a range of acceptable illumination, which must be neither too low, or too high in order to produce an acceptable image, and is known as the 'dynamic range'. This is directly analogous to a photographic camera, where the level of illumination reaching the film, or the 'exposure' must be controlled. The photographic camera will generally have an adjustable shutter speed which allows further control over the exposure. The combined benefits of shutter and iris control are many, allowing trade-offs between depth of field and the ability to capture images of fast moving scenes.

It is also feasible to control the effective shutter speed of a video camera. This could be done using a mechanical shutter, although a far more elegant approach is possible when using a CCD sensor. For the CCD, shutter speed control, often referred to as 'integration time', may be adjusted by purely electronic means. However, the photographic camera is capable of using extended 'shutter open' periods in order to capture an image at low light levels, whereas this presents a fundamental problem for the video camera. The video camera must deliver 25 pictures or 'frames' every second in order to remain PAL compatible. This limits the exposure time for each picture to an absolute maximum of 40 milliseconds, although many systems currently available infact have an upper limit of just 20 milliseconds (due to the interlacing of 2 'fields' per frame). This limitation has a significant effect on the sensitivity of a video camera to low light levels. If a longer exposure time or 'integration period' could be used, the sensitivity would be improved correspondingly.

The CCD sensor is itself capable of operation with exposure times of considerably longer than the 40 millisecond limit. Subjects which move during the 'shutter open' period will be blurred, and the problem becomes increasingly serious as we use longer periods. How ver, for many applications the capability of extreme low light level operation is an overriding benefit, and a blurred image would be pref rable to no image at all. This could be used to considerable advantage as a backup mode of operation where lighting has failed, or has been reduced to save power consumption.

The invention is a technique which allows a video camera to operate at extreme low light levels, using low cost CCD imager technology, by extending the integration time, while retaining compatibility with PAL (or some other) target system. The emphasis is on compatibility, such that the camera can be used with other equipment including video recorders, displays, and computer image capture systems. The technique is suitable for use with both colour and monochrome cameras.

Diagram 1 shows an internal view of a typical 'Interline Transfer' CCD sensor. This type of sensor is currently very popular, but other types are available (e.g. Frame Transfer). It shows the 'charge wells', which accumulate a charge proportional to the intensity of light arriving at the sensor, and the shift register structures used to read this charge and produce an output signal. The CCD charge wells are emptied or 'reset' every time the image is read.

Diagram 2 shows the major parts of a typical CCD camera. There is a CCD imager device, which receives signals generated by the timing and sync generator. These signals control the transfer of charge from the wells, and the major timing characteristics of the final video output signal. There is also a video output amplifier with Automatic Gain Control, which boosts the signal leaving the imager to a useful level. The AGC adjusts the gain of the video amplifier to produce a constant output level as lighting conditions vary. The output signal must contain timing reference signals which are produced by the timing and sync generator, and then added into the output signal by the video amplifier. Some systems may provide this separately.

Diagram 3 shows a CCD camera similar to that in diagram 2, but with electronic shutter speed control. The AGC is shown linked to the timing signal generator. It is through this link that control is exerted, since the timing generator governs the effective shutter speed or integration time. In strong lighting conditions, the integration time can be reduced by forcing extra reset cycles to occur. This can be used with or without a manual override.

Diagram 4 shows an embodiment of the invention. The CCD camera described above now carries a digital field or frame store system at its output, which is linked to the AGC system. The following description assumes that a field store is in use. The video amplifier is now used to set an appropriate input level for the field store. During normal operation, the integration time is less than the period of a field, and the field store is either bypassed, or is operated in a 'loop-through' mode. At very low illumination levels, the AGC is unable to produce a satisfactory result by simply increasing the video amplifier gain. In such conditions, the field store is used to record or 'capture' a field, and the integration time is extended by some factor determined by the AGC system. During this extended integration period, the sensor will be unable to provide an output signal, and so the image stored in the field store is used to produce output fields that fill the blank spaces. This is done repetatively until the integration is completed, when the field store is used to capture the new field. The output is thus a succession of identical images which are copies of the one which was captured, repeated at normal video rate until a new image is available from the imager. When illumination increases again, this is detected by the AGC system and the integration period is reduced as appropriate, reverting to normal operation in favourable lighting conditions. Many permutations are possible depending on the type of sensor to be used, and the required image quality. The captured image can be either a full Frame, or just a single field.

Diagram 5 shows a typical single-chip colour CCD. This is very similar to th monochrome type, except that the sensitive areas are behind coloured filters (a 'mosaic' filter). Thes filters allow only red, green or blue light to fall on the associated charge well. It is notable that there is still only one output signal, which contains the colour information in a serial form. This type of sensor is very popular as it is cheap to produce cameras that use them.

Diagram 6 shows a typical colour camera. A colour camera may be implemented using 3 separate (monochrome) CCD sensors with diplexing optics, or a single chip as desribed above.

Diagram 7 shows an embodiment of the invention, a colour camera with extended integration. Here it is seen that the output (s) from the sensor(s) can be digitised and stored in a memory prior to the colour encoder. The encoder will thus receive input signals either directly from the CCD(s), or having first been stored in the memory. In either case, the processing required to produce the compatible output signal will be the same. This is seen to be particularly efficient for the single chip type, where the serial information can be stored to and recalled from a single memory area, and delivered to the colour encoder as though it were direct from the CCD itself. The storage device could be placed after the colour encoder, which could have advantages if multi-standard compatibility was desired, although for a single standard this would be unnecessarily complex. Digital multi-standard converters are now commonplace. Typically, this would involve digitisation of the input, conversion from the input standard to some intermediate form, and subsequent conversion to the output form either with or without the capacity to store any of the signal forms.

Claims

1. A video camera capable of operation with image integration periods that may considerably xceed the period of a single frame of the output video signal (an "extended integration period"), comprising:
   An imaging device with direct or indirect integration time control
   An Image capture, store and replay device
   A control device which can increase the integration time beyond the period of a single normal output frame, utilising the above image store to repeatedly replay a previously captured image while the next new image is being acquired; thus ensuring a continuous video output signal which retains full compatibility with the intended target system or systems (e.g. 625 line PAL).

2. A video camera as claim 1, utilising a digital memory device to capture, store and replay the image singularly or in any desired plurality.

3. A video camera as claim 1 or 2, with the capability of extended integration periods linked to either a manual or automatic exposure control (or Automatic Gain Control), utilising an extended integration period to improve performance at low light levels.

4. A video camera as claim 1, 2 or 3, utilising an extended integration period as a means of backup operation after partial or complete failure of an active illumination system e.g. due to power failure or fault; or during periods of intentionally low illumination e.g. energy saving modes.

5. A video camera substantially as described herein with reference to the accompanying drawings.

The Patent Office

5

Application No: GB 9611570.4
Claims searched: 1-4

Examiner: John Coules
Date of search: 8 April 1997

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): H4F FCCB,FCCY,FCCX,FCK,FKX

Int Cl (Ed.6): H04N 3/15,5/217

Other: Online: WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB 2267407 A	(SONY) see repeat field generator 48 in fig 3 and field store 94 in fig 6; page 8 lines 8-11; page 10 line 31 to page 11 line 13	1 at least
X	GB 2166317 A	(PEARPOINT) see image store 11	1 at least
X	EP 0300365 A2	(TECHNION) see column 4 lines 28-35; column 7 lines 29-32; column 8 lines 14-29; column 11 lines 48-56	1 at least

X Document indicating lack of novelty or inventive step
Y Document indicating lack of inventive step if combined with one or more other documents of same category.
& Member of the same patent family
A Document indicating technological background and/or state of the art.
P Document published on or after the declared priority date but before the filing date of this invention.
E Patent document published on or after, but with priority date earlier than, the filing date of this application.